

Statement of Research Interests

Dr. Dmitry O. Litvintsev

The year 2004 marked the 30th anniversary of the discovery of the J/ψ , a narrow meson resonance which was interpreted as a bound state composed of a heavy charm quark and its antiquark. Interestingly, the existence of this fourth quark have been predicted earlier to explain absence of flavor changing neutral currents. An experimental discovery of the charm quark, soon followed by an observation of the bottom quark, turned the concept of quarks from a mathematical abstraction into physical reality, and boosted interest in quantum gauge field theories that later materialized in formulation of the Standard Model of electroweak interactions. The Standard Model describes interactions between fundamental fermions – quarks and leptons.

There are six quarks that can be divided into heavy and light sectors with respect to the QCD scale. The properties of hadrons, containing heavy quarks c or b , can be successfully calculated in the framework of the Heavy Quark Effective Theory (HQET) that provides a systematic expansion of the QCD Lagrangian in terms of inverse powers of the heavy quark mass. While HQET works best for the bottom hadrons, studies of charmed hadrons provide a valuable test of calculable ($1/m_c$) corrections to the HQET limit.

Production and decays of baryons containing charm quark were the subject of my research based on data collected by the ARGUS experiment at the DORIS II e^+e^- storage ring at DESY. I started with a measurement of $BR(\Lambda_c \rightarrow \Lambda \ell \nu X)$, and then moved on to a search for excited charmed baryon states decaying to $\Lambda_c \pi^+ \pi^-$. By the time my analysis activity began, ARGUS had stopped taking data and it was vital to obtain the largest possible sample of Λ_c by employing all accessible decay channels. The strategy turned out to be successful and I discovered the first orbitally excited charmed baryon state, the $\Lambda_c(2625)$. The discovery of the $\Lambda_c(2625)$ generated broad interest in the high energy physics community, and was quickly confirmed by the CLEO Collaboration which by that time had a much larger data sample than ARGUS. The mass and the width of the resonance, as well as the mass splitting between the lower lying $\Lambda_c(2593)$ state, were used to test many new theoretical predictions of mass spectra of excited baryons.

My interest in the heavy flavor baryons resumed when I had become a member of CDF Collaboration. The CDF detector operates at the world largest $p\bar{p}$ -collider Tevatron at $\sqrt{s} = 1.96$ TeV. At the Tevatron, unlike at dedicated e^+e^- B-factories that run at the center of mass energy of 10.4 GeV, all species of bottom hadrons can be produced in the process of b-quark fragmentation. The huge $b\bar{b}$ cross-section, a set of highly selective B-triggers coupled with the excellent tracking and good particle identification capabilities, all make CDF an ideal place to study bottom hadron production. Particularly, Tevatron is the unique place where bottom baryons are currently produced.

So far unobserved, bottom baryons containing s-quarks predominantly decay weakly to final states containing long lived hyperons Ξ and Ω . A successful reconstruction of the bottom-strange

baryons starts with an efficient extraction of clean Ξ and Ω signals. The long lifetimes of these hyperons suggest a unique method of their reconstruction by finding the charged hyperon tracks in the volume of the CDF silicon tracker. I have developed a new and original technique of dedicated tracking of long lived hyperons in the silicon tracker. Compared to the standard reconstruction of the decay particles, this method gives improved momentum and impact parameter resolutions and dramatically reduces the combinatorial background.

Recently the NA49 Collaboration announced an observation of the exotic $S=-2$ baryons, an unusual bound state of five quarks, called pentaquarks, decaying to $\Xi\pi$. Given my experience in baryons I was natural candidate to lead vigorous program of pentaquark searches at CDF. The preliminary results were reported at summer 2004 conferences and now are on the way to be published by Winter 2005.

The technology that I developed and the knowledge of subtleties of baryon reconstruction in hadron collider environment that I acquired and documented can be transferred to the future experiments like BTeV, LHCb and even CMS. In addition to expanding spectroscopy and lifetime measurements these experiments will be able to measure CP violation in bottom baryon decays directly applying my method of hyperon tracking.

In the future though, I intend to switch to high p_T physics. I am looking forward to taking an active part in the Large Hadron Collider (LHC) physics program which will commence in 2007/2008. I have already made a contribution to the CMS experiment, one of the two general purpose detectors at the LHC, when the choice of technology for the Very Forward Calorimeter (HF) was being made few years ago. A novel calorimeter based on detection of the Cherenkov light emitted by shower particles traversing quartz optical fibers embedded in the absorber has been proposed. I made conceptual design of the HF and played a key role in pushing the R&D project through technology choice Committee and then to the pre-production stage.

The CMS and ATLAS detectors which will record pp collisions at $\sqrt{s} = 14$ TeV are general purpose detectors with special focus on discovery of the Higgs boson. The cross sections of processes contributing to Higgs boson production are well known and while gluon fusion has the largest cross section there is substantial QCD background and few handles to distinguish it from the signal. Only decay products' transverse momentum and the resonance in the invariant mass spectrum can be used. The second largest production cross section is weak boson fusion (WBF). WBF produces two high- p_T tagging jets in the forward/backward region of the detector providing additional handle of background reduction. Another feature of the WBF is the lack of color exchange between the initial state quarks leading to suppressed hadron production in the central region. This is in contrast to the QCD backgrounds which typically involve color exchange and hence increased activity in central region. Imposing veto on jet activity around Higgs candidate should provide additional background discrimination power. The importance of WBF for low and intermediate mass Higgs has been realized quite recently. I propose to develop analysis of the SM and MSSM Higgs produced in WBF decaying starting from Higgs decays $\tau\tau$ pairs and then extending the program to more demanding decay modes.

During my involvement in the CDF data handling group I have acquired an expertise in management of large volume of data produced by working experiment. Currently CDF has accumulated on tape close to 1 petabyte ($1 \text{ PB} = 2^{50}$ bytes) of data. Processing of such an amount of data with physics analysis and Monte-Carlo simulations running simultaneously on the computer farms at Fermilab is becoming challenging task. The advantages of using globally distributed computing resources have been understood and now CDF is actively pursuing adaptation of its computing model to Grid requirements. I am playing a leading role in this transition. Being an author of the original CDF Run II Data File Catalog that keeps track of files within the CDF Data Handling system, I oversee transition of meta-data tracking system into new Grid-friendly framework. As a part of a tape system upgrade I designed, setup and executed the mass scale copying of all CDF data from an inadequate tape system into a robust and reliable state of the art Enstore managed Mass Storage System. The CDF experiment made first steps towards unloading central computing system by setting up Monte Carlo data production at remote sites, and I developed and setup reliable copying of the produced data back into Fermilab Mass Storage System.

As the head of the CDF data base project I lead a group of physicists and computing professionals to develop and operate existing CDF data bases. Compared to collider data, the information stored in the data bases is tiny, but no event reconstruction is possible without the constants stored there. I am working on adaptation of database applications to the Grid environment. Specifically I am working on minimizing the central database access by remotely running applications to limit the effect of network latency that adversely impacts efficient usage of computing resources.

At the LHC, the amount of data stored to tape will reach exabytes ($1 \text{ EB} = 2^{60}$ bytes). Storage, processing and analysis of such unprecedented volumes in the framework of a centralized computing model, where all computing power is concentrated at the host laboratory, will become an impossible task. The LHC experiments have adopted a model of multi-tiered hierarchy of computing power distributed across the globe. The successful use of this global ensemble of systems to meet experiments' scientific goals depends on the development of the Data Grids capable of efficient data distribution and job submission.

The work on some of these areas at LHC has just started. I have significant experience in providing robust data handling solutions at CDF which records data at the peak rate of 80 Hz, which is comparable with the 100 Hz rate expected at LHC and hence represents similar problem. I am able to provide leading contribution to LHC Data Management projects which is responsibility requiring significant effort.

To summarize, I outlined major areas of my research interests – studies of bottom hadron properties at current Tevatron experiments; developing data analysis algorithms for the LHC experiments; research and development of new particle detectors for the future experiments; design and development of data management systems that facilitate analysis effort at large scale experiments in the framework of distributed computing model.